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NETWORK-CENTRIC WARFARE AND INFORMATION TECHNOLOGY: THE STOCK  
MARKET AS A HISTORICAL MODEL

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Signature



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## **Introduction**

Network-Centric Warfare is a concept based on leveraging information technology to increase combat efficiency, where information technology will enable increased speed and access to information over a complex system architecture. The military commander will interact within this construct to extract the needed information to make and execute operational decisions. The essential benefits of information technology -- speed and access of information -- will enable a network-centric organization to derive combat efficiencies superior to the centralized information control of "platform-centric" organizations.

As recently as fifteen years ago, the stock market encountered a similar technological leap in information systems that revolutionized stock trade decision-making. The transition of the stock market, from centralized control of information to widespread information availability, created a network-centric environment for investors and money managers -- with impacts on strategy, execution, and decision-making.

Examining the parallel of the stock market to the network-centric battlespace, where decision-makers interact with speed-enhanced and volume-intensive information systems to enact time-sensitive high risk decisions, should yield that lessons learned from the stock market application of information technology provide relevant conclusions for a network-centric warfare organization. Basic models of network-centric warfare and stock market applications of information technology reveal supportive similarities for studying their impacts on the decision-maker, with only minor dissimilarities. Analysis shows that the relevant impacts are most closely associated with the increased speed and access of information available to the decision-maker. Speed and access induce time-compression in

the decision cycle and present the risk of information overload. In the stock market these dynamics -- speed and volume of information -- affected investors' decisions. Although a new strategy evolved that adapted to information technology, planning and training proved to be recurring solutions for capitalizing on the abundance of immediate information.

Much as the stock market response underscored the importance of planning and training to succeed in the new information-rich environment, operational commanders must also account for the induced effects of speed and access by planning and training for combat in a network-centric warfare environment.

### **Network-Centric Warfare**

Network-Centric Warfare focuses on the combat power that can be generated from the effective linking or networking of the warfighting enterprise.<sup>1</sup> Still in early concept stages, it purports to provide an efficiency of military force by leveraging advances in information technology. A "steady diet of timely, accurate information" is the empowering factor that enables shared battlespace knowledge in the network-centric force.<sup>2</sup> In the network-centric model, information technology will link decision-makers, sensors, and engagement weapons on a physical system where all units have rapid access to volumes of information, described in more detail in Appendix A. The information defines a common picture, providing shared battlespace awareness and enabling immediate coordinated engagement. This immediate access and shared awareness enables *speed of command*, where the Observe, Orient, Decide, Act (OODA) decision processing time of a network-centric force shrinks inside that of the enemy, improving combat command efficiency. Access to

information allows subordinate combat units to act immediately in relation to each other, or *self-synchronize*, without additional direction or span of control from a superior. The key factor that allows speed of command and self-synchronization is information. While tactical and operational advantages may overlap, the essence of the network-centric model is that information technology enables the networked warfighter to apply efficient combat power. Information technology increases the speed of access and the volume of information available to the networked warfighter.

In contrast, the present model of platform-centric warfare hinges on the combat power derived from stand-alone or isolated platforms, where information is disseminated through a centrally controlled structure. Platform-centric warfare depends on geographically separated information, resources, and engagement units, as depicted in Appendix A. The lack of a common information grid limits the information available to each unit, which weakens combat effectiveness and reduces the ability to quickly respond.<sup>3</sup> Platform-centric operations do not take advantage of the sharing of information and common awareness afforded by information technology. Essentially, Network-Centric Warfare (NCW) transitions from platform-centric operations where *a few had the majority of information at the top* to networked operations where *many have all of the information throughout*.

### **Stock Market Model**

The concept of network centrality did not originate in the military. Commercial organizations have long been leveraging information technology to gain the advantage and remain survivable in a business environment where information is paramount.<sup>4</sup> The stock

market experienced a similar revolution in information technology and investment decision-making within the fast paced, risk intensive, survival-of-the-fittest milieu of the stock trading world.

Prior to the mid-nineteen eighties, major stock market brokers and mutual fund managers had near-exclusive access to information regarding publicly traded companies; information that would take days or weeks to be made available to the public.<sup>5</sup> Privileged access to information allowed professional money managers to influence, direct, and enact stock trading decisions and execution for individual investors. Individual investors had sparse information on which to base decisions, and lack of timeliness of traditional transmission means, such as newspapers or periodic reports, degraded the relevance of available information. Although the money managers had access to information, it too was limited to slow delivery methods in a field where minutes or hours made a difference.<sup>6</sup> The centralized control of information effected a structure similar to platform-centric warfare, in which reduced access to timely information sub-optimized the investing decision.

Nearly overnight, the internet provided widespread information availability, removing the barriers and increasing the speed of information access for individual investors. Allen Sinai, chief economist at Shearson Lehman Brothers, noted that “overnight, the reaction time to market-influencing events dropped from months or days to minutes and seconds.”<sup>7</sup> Networked trading systems further allowed immediate access not only to information, but also to execution systems on the stock exchange trading floors.<sup>8</sup> The proliferation of information and the entrance of networked trading systems unfolded the centralized control and execution of trading actions, creating the stock market version of NCW’s sensor and engagement grids. A genesis of financial information web sites and online electronic

brokerage companies soon followed. These new companies multiplied speed of access to information for money managers, and provided speed *and* access for individual investors.\* A detailed description of this network-centric stock market model is provided in Appendix B.

The networked information and execution systems created a network-centric environment in the stock market. Investors gained the capability to gather information immediately and to act without consulting a mediating money manager.<sup>9</sup> Yet money managers also gained speed of access to critical information, allowing them to analyze and make decisions faster. For the stock market, “speed of command” and “self-synchronization” became realities, not concepts. The stock market transition from centralized control to networked-independent decision-making and execution parallels what network-centric warfare envisions for future combat operations.

### **NCW and the Stock Market: Model Comparison**

Implications of lessons learned depend, in part, on the coherence of the stock market and NCW models. Both models place all of the information gathering sensors, command and control decision-makers, and executing units onto a common, networked information backplane. Information technology, which enabled creation of the backplane, increased the speed of access to information for all networked units in each model. The stock market investor (or money manager) and the NCW warfighter both gained a significant speed

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\* For purposes of this paper, money managers are similar to operational commanders, and individual investors are similar to tactical units. Distinctions are made here to demonstrate how information technology and networking synthesized the different levels of the stock market’s command and execution structure and relate it to military levels of war.

advantage from previous system capabilities. The stock market and NCW models both put direct access to information directly in the hands of decision makers, and enabled direct control of their sensing and engaging entities -- the investor and the warfighter gained access to information that was not previously available, or was available with marginal limits of timeliness. From this comparison, the models correlate in their exploitation of the speed and access of information afforded by information technology, enabling faster, decentralized decision making.

There is, however, a divergence in the models in that investors and money managers do not act like warfighters with unity of command in a unit-cohesive team. Where warfighters value unity of command as a principle of war, investors and money managers act as separate, independently acting units. Network-Centric Warfare maintains the cohesiveness of combat units acting together, synchronizing and sharing information, to engage an enemy.<sup>10</sup> Money managers are more inclined to compete with other money managers than to cooperate towards the common goal, advertising their comparative results in order to gain investor accounts.<sup>11</sup> Individual investors, while not prone to compete with each other, are not likely to exert a collaborative effort to achieve wealth objectives that are not in their direct individual interest. The networked stock market model is therefore limited in that the units tied to the stock market network are not sharing information with other networked units to invoke *coordinated actions* towards the objective, as they are in the NCW model.

Despite this limit, the models maintain a level of coherence related to an element of unity. Similar to warfighters, each of the individual investment entities pursues a *common objective* upon which their efforts are focused -- for the investor or money manager, it is



increasing wealth through investing. The objective, and the ensuing focus of effort, is defined for the investor and money manager as clearly as it is for the warfighter. Adherence to an investment plan and its stated strategy is a principle of investing that focuses efforts on the objective -- financial goals.<sup>12</sup> Similarly, adherence to an operational plan and to the commander's intent focuses warfighting efforts on the achievement of the military objective.

The absence of collaboration does not prevent information sharing in the stock market model. In this model, information sharing results from the access inherent in the systems and through standardized reporting rules established by the governing Securities and Exchange Commission.<sup>13</sup> Investors simply arrive at a common picture and shared awareness for reasons different from the warfighter. The resulting use of information technology is the same in the stock market model as in the NCW model: a shared-awareness picture is developed, although inadvertently in the stock market model, from the access and speed of information made available, which is used to advance towards a common objective.

An additional divergence exists in the composition of forces for each model. In the NCW model there are *many* friendly units acting together as a combined team on a friendly network to engage, typically, a *single enemy/coalition* that is *not* on the same network. In this model, the OODA loop of the friendly force leverages information sharing from collaborative, networked friendly forces to expedite speed of decision making inside that of the enemy.<sup>14</sup> In the stock market model, there is a *single friendly* unit (the independent investor or money manager) acting alone against *many* enemy units -- all of the other investors in the stock market -- who are all on the *same* network. In the stock market model, there is no collaborative information sharing to optimize the friendly decision loop inside that of the "enemy" -- decision speed and access is equal and indiscriminate for all participants

engaged in stock trading. All investors – friendly *and* enemy units – are networked together. Optimization of the decision loop against that of a competing investor is a function of *training and experience* in the market -- not a product of the information system -- which allows an investor to sort and analyze the volume of information and gain a relative advantage.<sup>15</sup> In the NCW model, the system itself imparts a relative advantage – an operator operating on one network gains an advantage over one who is not networked, or networked on a separate system. NCW enemy and friendly units do not co-exist on the network grids as they do in the stock market model.

Though these divergences distract from precise correlation of the two models, the underlying essence of exploiting information technology remains valid. Both the NCW and the stock market models are based on access to universally available information, made possible by advanced information systems, to facilitate execution decisions in a dynamic environment. The operator -- decision-maker, warfighter, investor, etc. -- interacts with this technological construct to draw out the information he needs to make decisions. To extract lessons learned, *why* information is shared is not as important as *how* information technology is exploited to provide speed and access to information. As we have drawn the concept of network centrality from civilian applications, we may also draw lessons learned from this application - the positive and negative impacts of information technology on decision-making with the networked system. While lessons can be learned from a variety of corporations that have transitioned to networked information systems, the stock market provides a competitive environment upon which to study the implications of network centrality. Analyzing how speed and access of information affected the stock market

following the transition to network-centricity should enable the commander to better prepare for information-based operations in a network-centric warfare environment.

### **Lesson Learned: Effects of Information Speed**

The speed of information access has affected the way in which investors act in the networked stock market. The netting of investors to information, decision, and execution systems not only *allowed* investors to act immediately in the market, it *forced* them to do so.<sup>16</sup> Prior to networking the stock market, repercussions from new information played out over hours, days or weeks, allowing investors to absorb the information and analyze the total environment before executing a transaction decision. The rate of change in the stock price, or volatility, was related to the rate of receipt and reaction to information, which varied primarily due to methods of information transmission (newspaper delivery, broker phone calls, and analysts report mailings, to name a few).<sup>17</sup> Today, that investment decision cycle -- Event, Reaction, Result -- occurs in one one-thousandth the time that it did just fifteen years ago.<sup>18</sup> Information systems have nullified differences in rates of information transmission, providing, instead, information *access* as the prevailing driver to decision making, as the *speed* of information availability has become nearly instantaneous. The resultant increased tempo of the investment decision cycle causes a "time compression effect," where investors have to adjust by making execution decisions to buy or sell stock significantly faster.<sup>19</sup> The increased speed of information availability and ensuing investor reaction has caused a marked increase in the daily divergences in stock prices, creating a larger standard deviation over a shorter period of time. These rapid gyrations in prices

(volatility) induce an environment in which the price changes themselves are treated as information, and cause further reaction by investors.<sup>20</sup> A complicating aspect for the investment decision maker is the tendency to block out negative information once a decision is executed and stay with a position that may be counterproductive to their long-term goals.<sup>21</sup> The spiral that can follow -- investors reacting to their own actions versus reacting to actual new information -- can be dangerous. It is this phenomenon that is often blamed as the primary cause in market sell-offs.<sup>22</sup> Noted by Robert A. Brusca, Chief Economist at Nikko Securities, "We are learning that when we compress the time in which things happen, they happen differently."<sup>23</sup>

The stock market discovered that this destabilizing human factor accelerated as the rate of action increased. The existence of immediate trade execution aggravated investor irrationality -- investors felt the need to increase activity in a crisis since they had the *capability*, instead of rationally evaluating a situation against their predetermined investment strategy.<sup>24</sup> Where in the past, busy signals while telephoning the broker caused inadvertent "operational pause," today's netted trading systems have no similar barriers to slow the pace of action in stock market crises. The same information technology that has been heralded for availability and completeness of stock market information received failing marks for adversely affecting the investment behavior of shareholders.<sup>25</sup> The technology that was created to empower investors also amplified their pernicious traits.

Combat action parallels stock market crisis trading. Through danger, combat increases the emotional reaction of the warfighter and increases the unpredictability of interactions.<sup>26</sup> On July 3, 1988, the U.S.S. Vincennes shot down Iranian Air Flight 655 over international waters in the Persian Gulf. The ship's commander was acting in response to a

perceived imminent threat in a high tension environment – two groups of Iranian patrol boats and an Iranian P-3 aircraft were also maneuvering in proximity to the Vincennes. The compressed timing of the sequence of events that unfolded led to the tragic shoot-down of a civilian airliner.<sup>27</sup> In April 1994 two American F-15C fighters shot down two American Black Hawk helicopters over Iraqi airspace, killing 26 friendly troops and passengers. Emotions of the F-15C pilots in the high intensity environment during Operation NORTHERN WATCH overrode their adherence to the rules of engagement.<sup>28</sup> The F-15C pilots, enforcing a no-fly zone, had seven minutes to act from radar detection to target engagement.<sup>29</sup> Despite having that much time -- an eternity for a fighter pilot -- the pilots let the confusion brought on by their perceived speed of action override their adherence to the established plan. In both of these non-NCW incidents, time compressed the evaluation of information and resulted in unfortunate decisions. Network-Centric Warfare will allow further compression of the decision cycle through speed of information access.\*

The stock market assessed the increase in pace brought about by the speed of the systems to provide information and execution. Exchanges and market regulators have considered steps to “cool off the frenzy of activity... and allow investors to digest the overwhelming flood of information that causes hair-trigger decisions.”<sup>30</sup> Investors mirror combat leaders in their readiness to take positive action despite bad information.<sup>31</sup> Investment experts consistently stress the importance of developing and adhering to a trading plan -- executing the plan removes a majority of the irrationality caused by crisis psychology. Investors with immediate access to information and *control* of their accounts are actually less

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\* The hypothesis that NCW will provide *better* information faster, and will assist in preventing (as opposed to further complicating) future unfortunate events such as these will be discussed in the next section of this paper.

likely to panic or make hasty decisions in a volatile market environment.<sup>32</sup>

The self-synchronized warfighter must maintain unflinching cognizance of the capability to escalate irrational actions at an unabated, accelerated pace in network-centric combat. The speed afforded through self-synchronization can result in unintended actions. The determinant that will ensure stability of emotion in order to provide true *networked combat power* will be the clarity of and adherence to the operational plan. In evaluating the factor of time, operational commanders should account for speed-induced compression of events, and adapt branches that may ensue from actions -- friendly and enemy -- occurring in closer sequence than anticipated. Commander's intent should clarify what sequential actions are *not* desired in a self-synchronized NCW environment without specific approval of the operational commander.

### **Lessons Learned: Effects of Information Access**

The internet provides investors with seemingly unlimited information. Separating what is significant from what is insignificant is a daunting task. As Todd Shaver, editor of *The Bull Market Report*, observes, "On the internet there is no shortage of information, but wisdom is a valued commodity."<sup>33</sup> Investors demanded convenient, immediate, and independent access to information and control from their financial institutions.<sup>34</sup> In its effort to simplify investing and empower investors, the information network actually overwhelmed and complicated stock trade decisions. The volume of information made available, whether pulled from the network by specific demand or pushed to the investor through automated systems, can freeze investors who try to collate and analyze the abundant resources to extract

relevant information prior to making a decision. Robert A. Brusca, chief economist at Nikko Securities, advises that investors "shouldn't have to deal with information any faster than (they) can absorb it."<sup>35</sup> There is a concern that information overload will distract investors from making more accurate decisions. This concern has led some experts to advise investors to discount some information. Geoffrey A. Moore, author of The Gorilla Game: An Investor's Guide to Picking Winners in High Technology, advises investors "As you scan this flow of information, your goal should be to exclude, not include, new data -- otherwise you are going to drown."<sup>36</sup>

Further research finds that the concern of overloading an investor with a flood of information is confined to novice or casual investors -- not to the professional traders who are on par with professional military leaders. In the case of these professionals, advanced technology assists in handling the flood of information. Overwhelming information quantity can be filtered to manageable amounts as a function of procedure or through professional investors' screening systems. Professional futures traders found the information overload and decision paralysis hypotheses unwarranted. These traders were in the pits of the exchanges daily, continuously in the frenzied combat on the financial battlefield. They engaged in continuous decision-action cycles and absorbed data from multiple sources simultaneously with little loss of efficiency.<sup>37</sup> They use experience and quantitative tools to sort the important information from the inconsequential data. Their decision-making experiences, ability to adapt to volumes of information, and tenacity to trade in a crisis characterize trained and experienced professional investors. The traders learned not only to maneuver where the market has been, but also to stay ahead of where it is likely heading.

Applying the model comparison, the warfighter must earn NCW experience through action and training if he is to be effective in an information-rich combat environment. As the professional futures traders demonstrated, the ability to discern *static data* from *battlespace-relevant information* in a crisis results from the experience of engaging in continued decision-action cycles. The 1995 shoot-down of Captain Scott O'Grady's F-16 aircraft over Bosnia is an example where having data is irrelevant if it cannot be applied as accessible battlespace information. Reports claim that there were indications of a Serbian SA-6 missile threat hours before O'Grady's F-16 neared the missile's engagement envelope.<sup>38</sup> At least three airborne sensor platforms had some indications of the SA-6 system activity, which was not disseminated since it commingled within the intelligence analysis and reporting system.<sup>39</sup> Recall, too, that the U.S.S. Vincennes shoot-down of the Iranian airliner exemplified the need to extract relevant information from amassing data over a short period. Network-Centric Warfare netting of resources significantly multiplies the volume of data, such that the operational commander will incur a premium on reliable, quality information sifted from the network-centric battlespace.<sup>40</sup> As in the stock market model, there will be a requirement for quantitative filtering of intelligence and other sensor data to extract relevant information.

Carl Von Clausewitz expressed an aversion to operational intelligence, dismissing it as mostly false, compounded by the "effect of fear...to multiply lies and inaccuracies."<sup>41</sup> This can be more complicated when the network allows real-time, accelerated dissemination of unevaluated information or inaccurate data. In the stock market model, professional traders relied on experience, and quantitative tools, to pare the volume of information into relevant, manageable bits. In the NCW model, operational commanders and their joint units will need to gain experience by simulating information-intensive combat operations and



training in an information-rich environment. This training should provide experience in sifting the battlespace-relevant information out of amassing data and lessen the proliferation of inaccuracies throughout the networked information grid.

### **Lessons Learned: Adaptive Strategies**

Speed and access to information in the stock market changed the dynamic of investors executing their investment plan and strategy. Additionally, information technology created an entire new investing strategy and a new class of investor -- momentum investing by the day trader. The day trader, or momentum investor, learned to take advantage of the spiraling time compression effect mentioned earlier and trade into rising or falling markets with equal success. His effectiveness was not dependent on the direction of the market, but rather on his ability to quickly position himself to take advantage of its rate of movement. Through trial-and-error experience, he learned how to capitalize on the immediacy of information access and the speed of decision and execution systems.<sup>42</sup> By stark contrast, traditional investors -- led by icons such as Peter Lynch, Warren Buffett, and Benjamin Graham -- invoked a "platform-centric" investing strategy where individual analysis and methodical, independent exploitation of information were paramount for success.\* Whereas traditionalists stood by Warren Buffett, Chief Executive Officer of Berkshire Hathaway, who advised that "inactivity strikes us as intelligent behavior," momentum investors depended on the speed of action and immediate access to information.<sup>43</sup> Consequently there were two

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\*These icons are considered by many to be the Halseys, Jominis, and von Clausewitzs of the investing world, which reveres and studies their styles, techniques, and theories in hopes of mirroring their success.

fundamental approaches to incorporating information technology into an investment strategy: continue operations without changing the approach, or adapt to the new tool and environment.

Present experts of the investing community are at odds assessing the new information technology strategies versus the traditional investors' stoic approach. The attitude towards momentum investing varies from skeptical trepidation to hostile rejection.<sup>44</sup> Most pundits have not fully embraced momentum investing as a strategic concept that assures market-beating returns over *long* investment horizons, primarily because momentum investing does not have a long history upon which to be measured.<sup>45</sup> When measuring effectiveness by available recent results, momentum investors have outperformed their traditional counterparts by more than twenty-one percentage points over the past five years (during the incubation stage of stock market information technology).<sup>46</sup> At that pace a momentum investor's money would double in nearly half the time it takes for the fundamental investor. Not all momentum investors were profitable -- those who developed a plan to exploit information technology were more successful than those without a plan.<sup>47</sup>

The implications for network-centric warfare are significant. As systems had improved and created a new strategy for investing, so a new strategy for warfare will evolve from the advances in information systems. Military history is replete with examples of technological advances altering operational strategy. Armored vehicles modified infantry warfighting in the eighteenth century. The transition from sail to steam power and subsequent advent of the battleship significantly changed naval warfighting doctrine in the nineteenth century. Combat air power altered attack and defense strategies in the dawn of the twentieth century.<sup>48</sup> In each of these examples, forces that planned and trained to incorporate

the new technologies were able to leverage them into formidable combat power.<sup>49</sup>

Operational commanders should expect that present strategies will need to adapt to the speed and access advantages that information technology will afford. A re-evaluation of own and enemy courses of action in existing operational plans, with mindset towards the impact of NCW, will enable our forces to capitalize on information technology. It may be premature to conduct a review of our operational plans now, while NCW is "only a concept." However, as information technology evolves, periodic evaluation with an eye towards the future will help identify possible new strategies that can improve the achievement of the objective -- capitalizing on the lessons of the stock market.

### **Conclusion**

The network-centric warfare model and the networked stock market model both leverage the speed and access of information technology to enable decision-making efficiency in an environment of information volume. Speed of information expedites decision processing and enables faster decision-based actions than previous "platform-centric" models. Access to information in both models provides thorough knowledge of the operating environment, and the network makes this shared "information picture" available to all networked entities. Although these similarities in the models support a comparative analysis of lessons learned, the models are discovered to have only minor differences for the analysis of speed and volume of information in decision-making.

Despite the differences, the network-centric warfare model was consistent with the networked stock market model for assessing the effects of information technology. In the

stock market model, information technology compressed decision-making time and increased the volatility and unpredictability of events. Investors who adhered to an investment plan were less likely to be adversely affected by the ensuing volatility. Immediate access to volumes of information in the stock market model presented a potential to overwhelm the decision-maker. However, professional traders who garnered experience, trained, and planned strategies around the speed and access of information thrived in the crisis trading environment without getting information-induced decision paralysis. A momentum-based trading strategy evolved in the stock market model that capitalized on the speed and access in information technology. Investors who planned and learned how to implement the momentum strategy bested the performance of investors who continued to employ stoic, "platform-centric" strategies.

These lessons from the stock market model translate into actions and cautions for NCW operational commanders. Information technology affords benefits in speed and access of information. The increased speed and resultant self-synchronization of combat units can lead to subordinate units initiating or continuing actions beyond the intent of the operational commander. The increased speed may also cause forces to react to their own actions before the enemy has a chance to respond, inducing combat risk -- just as volatility was increased in the stock market. The prudent operational commander should, in his concept of operations, account for unintended actions which network centricity may invoke, and clearly stipulate in his intent the limitations of actions for his subordinate units. Branches should also be investigated that identify likely friendly or enemy reactions caused by the time-compression of events. A review of operational plans should also be conducted, focused on evaluating and comparing own and enemy courses of action, to capitalize on the benefits of information

speed and access. Since events may unfold differently in NCW operations than expected in platform-centric operations, this review may discover an alternate, superior strategy for achieving the operational objective by leveraging the benefits of NCW. Although these planning recommendations are not time-critical, they will become more important as network centricity evolves out of the concept phase.

In addition to speed, access to volumes of information complicates the decision-making process and places substantial value on the ability quickly to derive battle-relevant information out of mass amounts of data. Commanders should construct and employ exercises focused on the extraction of information simulating a data-rich environment. Experience should be gained in netted unit operations *before* a crisis occurs.

The lessons of the stock market model when applied to network-centric warfare reveal that the speed and access enabled in an information-rich environment will benefit the warrior that plans and trains for network-centric operations.

## **APPENDIX A**

### **NETWORK-CENTRIC WARFARE MODEL**

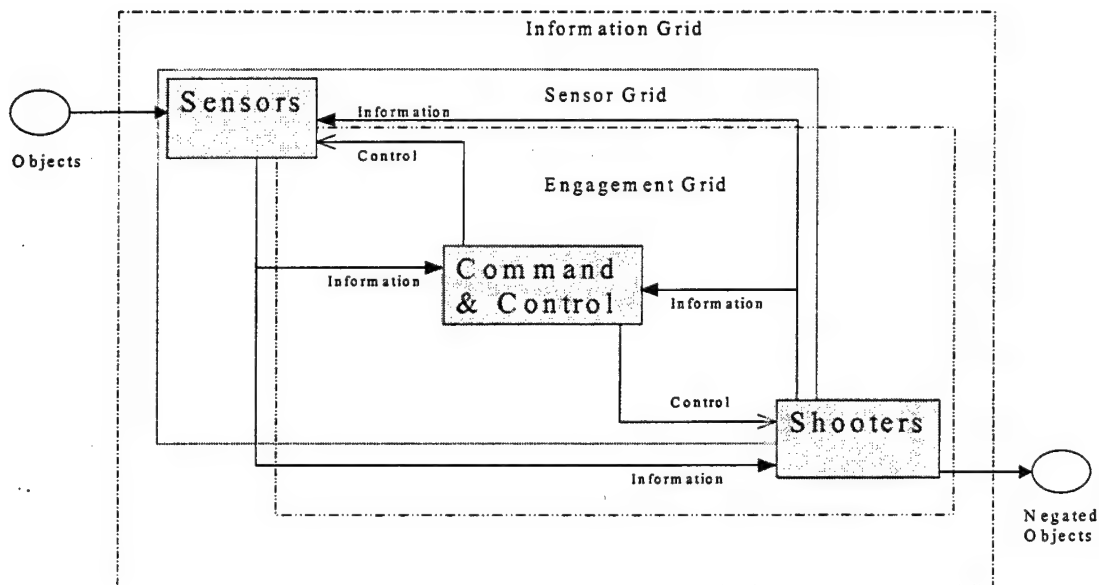


Figure 1. Logical Model for Network-Centric Warfare.

In general terms there are three physical networks, or grids, that overlap and provide feedback to form a single network that encompasses all of the friendly forces on a single network: the Sensor Grid generates battlespace awareness; the Engagement Grid translates awareness into executed combat power; and the Information Grid provides the backbone of information which enables decision-making.

The concept uses information technology to build a backplane grid of information. All friendly units, and *no* enemy units, are “networked” on this information grid: sensor units, command and control units, and engagement units. Information is immediately available to all units due to the inherent nature of networked information systems. No longer do units need to wait until information is filtered through separate units and disseminated through non-real time methods, as in platform-centric operations. This enables “speed of command” in operations, where subordinate and decision making units are not limited by transmission times or lack of information.

The common information system enables construction of a common battlespace picture, available immediately to all networked units. Since all units have the same information and a common picture of the battlespace, they are afforded the ability to act on that information without delay (systematically, not procedurally). This enables “self-synchronization” in operations, where units can act in unison from their knowledge of what other coordinating units are encountering.\*

\* Arthur K. Cebrowski and John J. Garstka, “Network-Centric Warfare: Its Origin and Future,” U.S. Naval Institute Proceedings, January 1998, 31-33.

For general comparison, an illustration of a platform-centric model is provided in Figure 2.

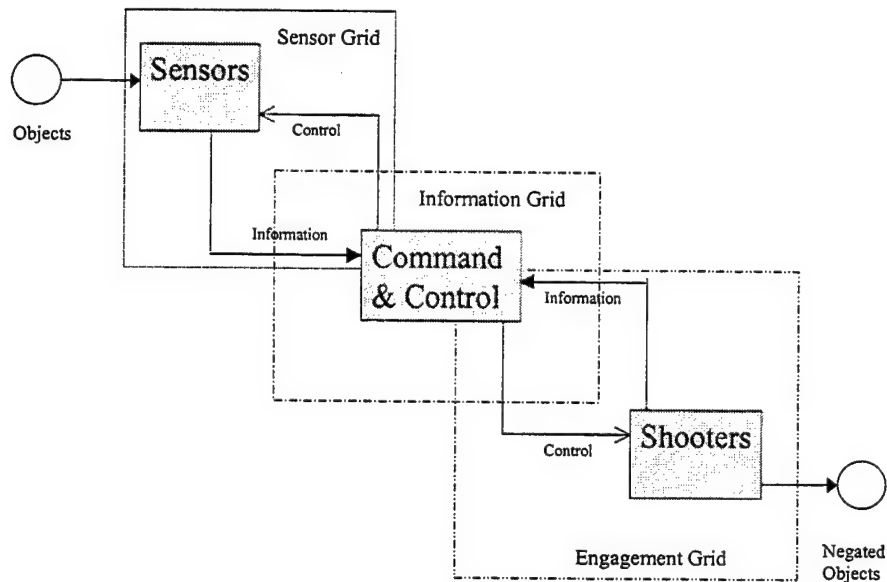


Figure 2. Model of "Platform-Centric" Warfare.

The platform-centric force does not share a common information structure from which forces draw shared battlespace awareness. Engagement and decision-making units are dependent on information filtering through command-controlled, and often physically and geographically detached, sources, which rely on non-real time or near-real time information transmission systems.



## **APPENDIX B**

### **STOCK MARKET MODEL**

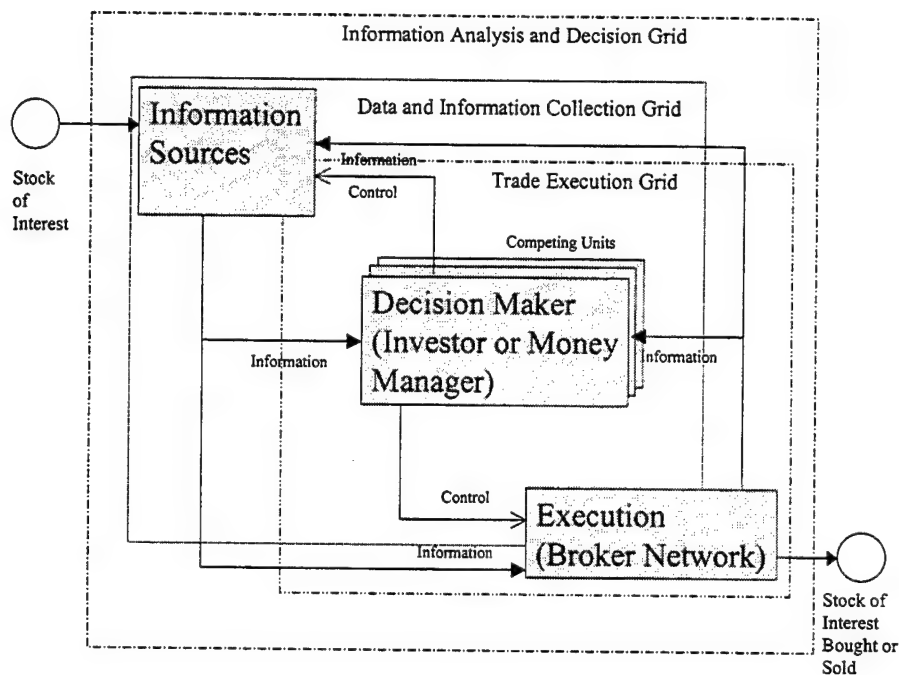


Figure 3. Model of "Network-Centric" Stock Market.

The stock market network combines stock market investors (including those competing with each other) onto a single network. This network encompasses information resources, decision-makers (investors and money managers), and execution entities. The network has an information backplane, the commercial internet, that ties together the units through information systems that allow information sharing and control inputs. The network is not limited to friendly access; typically, multiple competing investors share the same information and execution resources, making this model less bi-polar than the NCW model.

The stock market model enables a decision-maker (investor or money manager) to:

1. Collect information from all resources (company reports, expert opinion, analysts recommendations, financial data, new releases, etc).
2. View a graphic representation of the situation (price history charts, technical analysis of stock price and trading volume movement).
3. Compare courses of action (buy and sell recommendations, financial ratio comparisons).
4. Execute a decision, eg. trade stock, through a broker unit.
5. Follow-up (track portfolio performance, set buy and sell limits, automate news and price alert signals).

The network backplane enables immediate access to information, which expedites the ability for an investor or money manager to make a transaction decision. Investors and money managers are able to immediately control information resource entities and

transaction-execution entities through the information backplane grid.\*

Notice that investors moved to join money managers in the central decision-making position of the networked stock market model (Figure 3) from an external position in the "platform centric" model (Figure 4). Analyzing money managers and investors separately becomes insignificant at this point in the networked stock market model. The impact of lessons learned by analyzing only the effect on investors applies to both investors and money managers, and therefore to both operational and tactical commanders in the NCW model.

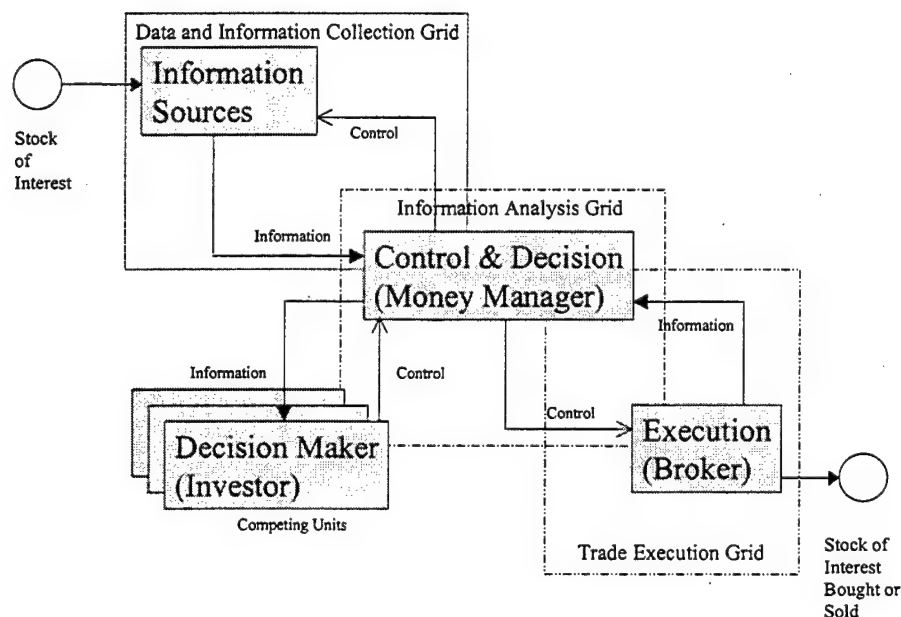


Figure 4. Depiction of "Platform-Centric" Stock Market Environment.

Prior to information technology changing the stock market information and execution systems, individual investors had limited access to timely information, typically filtered through a money manager.

\* "National Poll Indicates Online Investing is Wave of Future," PR Newswire, 10 September 1998. (Lexis-Nexis. New York: PR Newswire Association, Inc.); "E\*TRADE Launches New Destination Web Site and Stateless Architecture to Empower Individual Investors," PR Newswire, 10 September 1998. (Lexis-Nexis, New York: PR Newswire Association, Inc.); Heather Fondo, "E\*TRADE Expands Investor Education Commitment with Launch of the Knowledge Center," PR Newswire, 15 November 1999. (Lexis-Nexis. Menlo Park, CA: PR Newswire Association, Inc.).

## NOTES

<sup>1</sup> David S. Alberts and others, Network Centric Warfare: Developing and Leveraging Information Superiority. (Vienna, VA: Department Of Defense C4ISR Cooperative Research Program, 1999), 88.

<sup>2</sup> Ibid, 91.

<sup>3</sup> Ibid, 90.

<sup>4</sup> Ibid, 25.

<sup>5</sup> "National Poll Indicates Online Investing is Wave of Future," PR Newswire, 10 September 1998. (Lexis-Nexis. New York: PR Newswire Association, Inc.).

<sup>6</sup> John C. Bogle, "To What Avail? Computer Technology and Mutual Funds," Lecture, Grant's Spring Investment Conference, 3 April 1997. (Lexis-Nexis. New York: The Vanguard Group), 2-3.

<sup>7</sup> Allen Sinai, quoted in David E. Sanger, "New Reliance On Computers Is Altering Investors' Tactics," The New York Times, 15 December 1987. (Lexis-Nexis. New York: The New York Times Company).

<sup>8</sup> Office of New York State Attorney General, "From Wall Street to Web Street: A Report on the Problems and Promise of the Online Brokerage Industry," 22 November 1999, <[http://www.oag.state.ny.us/investors/1999\\_online\\_brokers/brokers.html](http://www.oag.state.ny.us/investors/1999_online_brokers/brokers.html)>, 34-40.

<sup>9</sup> Christos M. Cotsakos, quoted in "National Poll Indicates Online Investing is Wave of Future," PR Newswire, 10 September 1998. (Lexis-Nexis. New York: PR Newswire Association, Inc.).

<sup>10</sup> David S. Alberts and others, Network Centric Warfare: Developing and Leveraging Information Superiority. (Vienna, VA: Department Of Defense C4ISR Cooperative Research Program, 1999), 108-109.

<sup>11</sup> John C. Bogle, "To What Avail? Computer Technology and Mutual Funds," Lecture, Grant's Spring Investment Conference, 3 April 1997. (Lexis-Nexis. New York: The Vanguard Group), 4; Morningstar.Com Mutual Fund Advanced Screening. n.p. <<http://screen.morningstar.com/fundsearch/fundinterim.html>>.

<sup>12</sup> "Stocksystem.com Releases New Trading Software for Long-Term Investors," PR Newswire, 20 November 1999. (Lexis-Nexis. Orlando and Jacksonville, FL: PR Newswire Association, Inc.).

<sup>13</sup> Office of New York State Attorney General, "From Wall Street to Web Street: A Report on the Problems and Promise of the Online Brokerage Industry," 22 November 1999, <[http://www.oag.state.ny.us/investors/1999\\_online\\_brokers/brokers.html](http://www.oag.state.ny.us/investors/1999_online_brokers/brokers.html)>, 59-63, 72-76.

<sup>14</sup> Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origin and Future," U.S. Naval Institute Proceedings, January 1998, 33.

<sup>15</sup> F.J. West, Jr., "War in the Pits: Marine-Futures Traders Wargame," National Defense University Strategic Forum Number 61, February 1996, <<http://www.ndu.edu/inss/strforum/forum61.html>>.

<sup>16</sup> Edward Chancellor, "Another Quick Delve into the Fund of Stupidity," Financial Times (London), 24 July 1999. (Lexis-Nexis. London: The Financial Times Limited); Donald Ratajczak, "Evidence Mounting That

Online Trading Isn't for All," The Atlanta Journal and Constitution, 28 November 1999. (Lexis-Nexis. Atlanta: The Atlanta Journal and Constitution).

<sup>17</sup> This is the author's observance gathered from the themes inherent in investing periodicals consulted while researching this paper. Statistical data is not compiled in one single source to substantiate a crediting citation.

<sup>18</sup> Michael Makowsky, "Part Two - The Bull Market Report for the Weekend, January 15-16, 2000," 16 Jan 2000. (Listserv message, <weeklybullmkt-owner@listbot.com> via <<http://www.bull-market.com>>).

<sup>19</sup> Ibid.

<sup>20</sup> Roger Taylor and John Labate, "Age of the Day Trader," Financial Times (London), 9 February 1999. (Lexis-Nexis. London: The Financial Times Limited); Adi Satri, "Volatile Stock Markets Exert Frustration and Pressure on Investors," Berhad Business Times, 10 July 1995. (Lexis-Nexis. Malaysia: New Straits Times Press (Malaysia)).

<sup>21</sup> Edward Chancellor, "Another Quick Delve into the Fund of Stupidity," Financial Times (London), 24 July 1999. (Lexis-Nexis. London: The Financial Times Limited).

<sup>22</sup> David E. Sanger, "New Reliance On Computers Is Altering Investors' Tactics," The New York Times, 15 December 1987. (Lexis-Nexis. New York: The New York Times Company).

<sup>23</sup> Robert A. Brusca, quoted in David E. Sanger, "New Reliance On Computers Is Altering Investors' Tactics," The New York Times, 15 December 1987. (Lexis-Nexis. New York: The New York Times Company).

<sup>24</sup> Edward Chancellor, "Another Quick Delve into the Fund of Stupidity," Financial Times (London), 24 July 1999. (Lexis-Nexis. London: The Financial Times Limited); David E. Sanger, "New Reliance On Computers Is Altering Investors' Tactics," The New York Times, 15 December 1987. (Lexis-Nexis. New York: The New York Times Company).

<sup>25</sup> John C. Bogle, "To What Avail? Computer Technology and Mutual Funds," Lecture, Grant's Spring Investment Conference, 3 April 1997. (Lexis-Nexis. New York: The Vanguard Group), 8-9.

<sup>26</sup> Carl von Clausewitz, trans. and ed. by Sir Michael Howard and Peter Paret, On War. (Princeton, NJ: Princeton University Press, 1976), 138-139.

<sup>27</sup> Crowe, William J. Jr, "The Vincennes Airbus Tragedy; Gulf Experience, Bad Data Led to Cruiser's Attack Error," The San Diego Union-Tribune, 10 September 1989. (Lexis-Nexis. San Diego: The San Diego Union-Tribune); Lerner, Eric J., "Lessons of Flight 655: Destruction of an Iranian Airliner by the U.S.S. Vincennes Leaves Many Disturbing Questions," Aerospace America, April 1989. (Lexis-Nexis. n.p.: American Institute of Aeronautics and Astronautics).

<sup>28</sup> Auster, Bruce B., "The Perils of Peacekeeping," U.S. News and World Report, 25 April 1994. (Lexis-Nexis. n.p.: U.S. News and World Report).

<sup>29</sup> Starr, Barbara, "'Shocking' Errors Led to UH-60 Shootdown," Jane's Defense Weekly Vol. 22 No. 3, 23 July 1994, 11.

<sup>30</sup> David E. Sanger, "New Reliance On Computers Is Altering Investors' Tactics," The New York Times, 15 December 1987. (Lexis-Nexis. New York: The New York Times Company).

<sup>31</sup> L. D. Holder, "Offensive Tactical Operations," Military Review, December 1993, 54.

- <sup>32</sup> Christos M. Cotsakos, quoted in "National Poll Indicates Online Investing is Wave of Future," PR Newswire, 10 September 1998. (Lexis-Nexis. New York: PR Newswire Association, Inc.).
- <sup>33</sup> Todd Shaver, "The Bull Market Report for the Weekend, January 8-9, 2000 - Part One," 9 Jan 2000. (Listserv message. <weeklybullmkt-owner@listbot.com> via <<http://www.bull-market.com>>).
- <sup>34</sup> Christos M. Cotsakos, quoted in "E\*TRADE Launches New Destination Web Site and Stateless Architecture to Empower Individual Investors," PR Newswire, 10 September 1998. (Lexis-Nexis. New York: PR Newswire Association, Inc.).
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- <sup>38</sup> Mann, Paul, ed., "What Did Happen?" Aviation Week and Space Technology Vol. 143 No. 1, 3 July 1995, 17; "Perry Urges Speedy Data Targeting," Jane's Defense Weekly Vol. 23 No. 25, 24 June 1995, 4.
- <sup>39</sup> Ibid.
- <sup>40</sup> Thomas P. M. Barnett, "The Seven Deadly Sins of Network-Centric Warfare," U.S. Naval Institute Proceedings, January 1999, 39.
- <sup>41</sup> Carl von Clausewitz, trans. and ed. by Sir Michael Howard and Peter Paret, On War. (Princeton, NJ: Princeton University Press, 1976), 117.
- <sup>42</sup> Roger Taylor and John Labate, "Age of the Day Trader," Financial Times (London), 9 February 1999. (Lexis-Nexis. London: The Financial Times Limited).
- <sup>43</sup> Warren Buffett, quoted in John C. Bogle, "To What Avail? Computer Technology and Mutual Funds," Lecture, Grant's Spring Investment Conference, 3 April 1997. (Lexis-Nexis. New York: Vanguard Group), 4.
- <sup>44</sup> John C. Bogle, "To What Avail? Computer Technology and Mutual Funds," Lecture, Grant's Spring Investment Conference, 3 April 1997. (Lexis-Nexis. New York: The Vanguard Group), 4.
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<sup>48</sup> Beaumont, Roger, War, Chaos, and History, Westport, CT: Praeger Publishers, 1994, 46-60.

<sup>49</sup> Ibid, 153-154.

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